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ABSTRACT

Factors influencing the learning of mathematics in the linguistically diverse classroom are examined, drawing on the literature of mathematics and science instruction and of multicultural education. Teachers are encouraged to be aware that several linguistic, cultural, and cognitive factors affect the learner's academic performance, and to use linguistically and culturally sensitive instructional methods and activities to ensure success in math. First, a rationale for multicultural math instruction is presented, and then the relationship between language and math is examined in terms of the specific needs of limited-English-proficient students. Finally, some pedagogical implications and recommendations for classroom activities are offered. The latter include word problems that encourage repetitive language use, concrete and sensory experiences, cooperative activities that encourage interpersonal contact and problem-solving, writing and rewriting math problems, and songs and rhymes. (MSE)

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Teaching Math And Science To Language Minority Children: Implications For Teachers

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Abstract

Given the increasingly multicultural nature of today's classroom, teachers should provide ingredients for success based on the needs of their students. In light of these needs, this study provides a rationale for multicultural math that might help teachers working with students in diverse settings; it presents teachers with the necessary information about language minority children in math classrooms. It focuses on promoting sensitivity to the cultural, linguistic, and cognitive characteristics of diverse learners as they relate to the learning and teaching of math. The discussion also includes theoretical and pedagogical implications for teachers to ease the processing of math by language minority children. Finally, this paper offers teachers with guidelines for classroom strategies and activities relevant to the needs of LEP students in culturally diverse environments.

Teaching Math And Science To Language Minority Children: Implications For Teachers

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Introduction

Math teachers in the culturally diverse classroom are facing the challenge of meeting the specific needs of their students. These students bring in to the classroom a set of differences that have for a long time been ignored. The current trends in educational reform stress the understanding of the learners' needs. Thus, the teaching methods have to be assessed in terms of the desired educational outcomes as they relate to the needs of diverse learners. Research indicates that language minority students are taught math in methods that do not fit the specific needs of these students (Oakes, 1985; Secada, 1991; Deyhle, 1992). This involves the lack of considering the linguistic and cultural background of language minority children associated with the learning of math (Padron & Waxman, 1992).

For a long time the blame has been placed on the language background of the minority student. Although the early cognitive development in children may be universal, the way in which learning develops is bound to the culture the child is exposed to in the early stages of life. The relationship between math learning and English development has been debated by researchers in the field. Some claim that the learner's inability to speak English interferes with the learning of math (Kimball, 1990; Mather & Chiodo, 1994). However, given what we know about learning and the universality of intelligence in all children, it would be unwise to build on what children can't do rather than what they can do. The problem then lies in math lesson formats and methods that may not be consistent with the diverse experiences of children (Padron & Waxman, 1992; Mather & Chiodo, 1994).

Apart from the instructional techniques, another major problem teachers face in math instruction deals with motivation. To motivate learners of math, teachers must convince their students about the importance of math in their lives (Reyhner & Davison, 1993). The motivational and attitudinal factors relate to the way math is delivered; when math is made easy students tend to develop positive feelings towards learning it. Also, math should not be looked at in terms of utilitarian purposes only; learners must be prepared to become math-competent to live meaningfully in the highly technological global society. In short, orientations toward math learning should be both integrative and instrumental; integrative in a sense that math is a crucial part of the education of the individual, and instrumental in that math is a useful tool in almost all aspects of life. However, when adequate conditions for effective learning of math are present, motivation and positive attitudes will develop. Finally, teachers' expectations should be congruous with the intelligent nature of their students regardless of their background. If teachers strongly believe in their students, learning will take place. The power of positive thinking in learning and teaching situations can not be undermined; in fact, it is considered as a prerequisite for effective learning.

The purpose of this paper is to address some of the factors that influence the learning of math in linguistically diverse classrooms. Since several linguistic, cultural, and cognitive factors of the learners affect his/her academic performance, teachers dealing with students from diverse backgrounds must be cognizant of the role of these different variables. Teachers must utilize linguistically and culturally sensitive instructional methods and activities to ensure the success of math students. First, a rationale for multicultural math will be presented. Second, the relationship between language and math will be addressed in terms of the needs of limited English proficient (LEP) students. Finally, some pedagogical implications and recommendations for classroom activities will be suggested.

Why Multicultural Math?

Given the increasingly diverse society we live in, the make-up of today's classrooms deserves special attention. In fact, demographic changes have influenced the American public school system in many ways. One of the main trends in educational reform is to incorporate multiculturalism in the schools. In its whole premise, multicultural education is seen as a multidisciplinary, comprehensive approach that values and celebrates the diversity of student populations. In particular, multicultural education attempts to divulge students' potential and maximize learning opportunities for all students. This includes giving students the opportunity to learn as many languages as possible to augment their understanding of human experience. It also involves pinpointing the universal elements of education in all areas including mathematics and science.

Moreover, in an attempt to achieve its goals multicultural education aims to sensitize teachers and curriculum designers to the unique, specific needs of culturally diverse learners. In so doing, contributions of all cultures must be addressed in the curriculum and classroom activities. This should not solely become a component to be infused in language and social studies classes; it should include all contributions of all cultures to all fields of inquiry.

In mathematics and science classrooms, one can hardly see any sensitivity to students from diverse cultural backgrounds. Needless to say, the instructional techniques in these classes largely ignore the minority child because of the incongruence between the learning characteristics and teaching methods. Using a multicultural perspective, Twiest (1992) argues that successful math experiences are "the result of teaching and expanding concepts that have relevance and meaning in all children's lives" (p. 37). To do so, we should weave in the underlying principles of multiculturalism and incorporate them in the educational goals.

Multicultural education in general, and multicultural math in particular, is seen as a way to improve not only education for language minority children (Ogbu, 1995), but also

an imperative need for educational reform. (Banks, 1994; Banks, 1995) suggests a four-level approach to such reform in the education that can be applied to math and science education. This multi-level conceptualization includes the action approach, the transformation approach, the additive approach, and the contributions approach. These approaches can serve as a useful tool in promoting math and science skills in multicultural settings. First, students are encouraged to take action to solve learning including math and science problems in terms of their meaningful way of interaction bound to the social and cultural make-up. Second, the multiculturally transformed math and science curriculum enables learners to view math and science concepts and meanings in terms of cultural diversity. Furthermore, students are afforded with added universal elements of science and math that enrich their educational opportunities in math and science classrooms. Finally, students see themselves and their cultures through the contributions of pioneers and leaders in math and science who represent these students in today's classrooms.

Thus, it is compelling than ever before to induce multiculturalism in content area instruction. The specific educational goals of this mission has to be part of the math curriculum and pedagogy. Some of these goals are: (1) provide math resources consistent with the social and educational demands of the global technological society; (2) motivate all students to learn mathematics; (3) highlight contributions of all cultures in the area of math and science; (4) adjust teaching to the unique learning styles of students of math; (5) prepare teachers of math to effectively respond to the cultural and linguistic variables affecting the acquisition of math.

According to the recommendations of the National Council Of Teachers Of Mathematics (NCTM, 1989), students should be afforded with the opportunity to have varied experiences pertaining to cultural, historical, and scientific aspects of the evolution of mathematics, so as they can appreciate the significance of math in today's changing global society. In addition, the American Association for the Advancement of Science (AAAS) encourages an effective pedagogy in math classrooms, free from any form of bias

and prejudice: "It is important . . . for students to become aware that women and minorities have made significant contributions in spite of the barriers put in their way by society; that the roots of science, mathematics, and technology go back to the early Egyptian, Greek, Arabic, and Chinese cultures; and the scientist bring to their work the values and prejudices of the cultures in which they live" (In Addison-Wiseley, 1993, p. 3).

To implement this mission in today's classroom, teachers ought to build on the strengths of their students. In particular, when working with limited English proficient (LEP) students, multicultural materials should be utilized in math instructional techniques to "humanize mathematics and science by showing that these fields developed as a human response to human needs" (Addison-Wiseley, 1993, p. 3).

Because of the limited proficiency in English, minority students may find it difficult to unlock meanings in math lessons. Thus, teachers should understand the role of language in communicating math concepts.

Math and Language Minority Children

Like language, which is a universal human phenomenon, math has universal components as well. The contributions of current linguistic theory in its study of world languages have increased our understanding of language, its dynamics, functions, and its significance to the cognitive and social development of children. Likewise, the contributions of world civilizations to the area of math and science should be addressed in the math and science curricular activities and instructional techniques. We hardly hear about the contributions of various cultural groups to the flourishing of math and science throughout history; ironically students in today's classroom have come to represent these contributions.

A 1993 book published by Addison-Wesley compiled a reader on the accomplishments of ancient and new innovations in math, science and technology. The book is a synopsis of articles tracing the foundations of math and science; it attributes the current revolution in these areas to the basics of math found in diverse exotic cultural groups ranging from the Italians, Spanish, Greeks . . . to the Arabs, Persians, Indians . . . to the Native Americans and many others. For instance, more than 5000 years ago, African mathematicians and scientists created the basics for geometry as reflected in the ancient sculptures and artifacts. Also, the Persian and Muslim scientists created algebra as an independent field of inquiry. Moreover, the Native American civilizations have contributed in many ways to the fundamentals of erecting dams, skyscrapers, railroads based on their scientific and mathematical accomplishments. In fact, some of the prominent terms in math and science provide ample testimony for the credit that should be given to these cultures; e.g. the numeral system used in English and many languages is Arabic in origin along with some terms such as *algebra*, *zero*, *algorithm* and so on. Without these contributions, humanity would not have reached the current state of scientific and technological advancements.

Since mathematics has flourished throughout history due to scientists and mathematicians from various cultures, it would be fruitful then to look into the relationship between math and the language in which it is processed by diverse populations.

Students from linguistically diverse background usually come to school with a basic understanding of math concepts given their underlying cognitive abilities (Chamot & O'Malley, 1987; Cummins, 1989). The relationship between language development and cognitive, linguistic, social, academic, and intellectual growth of children in multicultural/multilingual settings has been thoroughly investigated by several researchers in the field (O'Malley & Chamot, 1990; Garcia, 1991; Hakuta, 1986, Krashen, 1981). Evidence is provided that bilingual instruction is beneficial to the child and contributes to his/her success in school (Hakuta, 1986; Garcia, 1988). The overwhelming evidence provided by these studies and others (see e.g. Banks & Banks, 1995. Handbook of Research on Multicultural Education) has contributed to our understanding of the role of the child's primary language in learning mathematics and science. The conclusions of these studies have useful implications for teaching math in multicultural settings.

It is worthwhile to investigate the role of language in math classrooms. In his investigation of the relationship between first and second language development in young children, Cummins (1989) argues that proficiency in the first language can transfer to the second language; for example, if a child is an effective writer in his/her native language s/he is likely to have effective writing skills in the second language. Hakuta (1986) also maintains that cognitive skills do not have to be re-learned by the child in the second language. Then, it can be argued that a student who has developed math skills in his/her native language is likely to transfer these skills in the language s/he is learning. Our observations of the large number of international students over the years who study math, science, engineering and the like at American colleges and universities support these findings. Generally, these students excel in math and science because they have the foundations through instruction in their native languages. For example, in his research on

EFL students, Suleiman (1993) concludes that the motivation and attitudes of Arabic speaking students towards the subject matter is influenced by the language of instruction. That is to say, when a student from this unique background is studying math, science, or engineering, s/he finds it easier to substantiate the concepts of math in their native language; the only barrier to mastering math involves the difficulty in making the linguistic adjustment.

Similar findings about difficulty in learning math as it relates to language, culture, and cognitive styles of the language minority child (Davison & Schindler, 1988; Garcia, 1991; Ogbu, 1995), have prompted researchers to investigate the reason why language minority children achieve less in math. For example, Reyhner & Davison (1992) investigated the role of "ethnomathematics and ethnoscience" as they relate to the LEP child's interests and needs. They conclude that using bilingual multicultural materials and instructional techniques "will make it easier for LEP students to buy into schooling" (p. 550). Focusing their research on LEP American Indian students, Reyhner & Davison (1992, pp. 570-572) provide the following recommendations and conclusions:

1. Teachers must relate to their mathematics instruction to the out-of-school life of their students;
2. The implementation of ethnomathematics can help teachers relate to those subjects in their students' out-of-school lives;
3. Teachers must "contextualize" what they teach;
4. Teachers need to be concerned about the affective factors in the classroom;
5. Teachers of math and science need to provide writing and other language development activities for their LEP students.

Closely related to our focus is that the notion about the creative aspect of language use, a view prominent in current linguistic theory and cognitive psychology, is similar to the creative aspect of math processing. Given the problems and demands of certain speech events, language users creatively rely on their linguistic competence to interact

meaningfully. Similarly, when students are given a math problem, they have to create solutions relying on their psycholinguistic strategies. Since every language utterance is unique to that individual, every math solution will be also unique.

Second language learners in particular tend to rely on what they know about math when solving its problems. They usually tend to interpret math in their native languages and attempt to present solutions in the target language. The problem lies in the culture-bound connotations and denotations when English is used for math instruction in culturally diverse classrooms.

These universal processes of math are mandated by certain parameters of the language of the learner; today's classroom abounds in these parameters. In second language classrooms, math learners tend to utilize some of these aspects by virtue of what they know about math in their native languages and cultures. In an all-English instruction settings, this might result in an inventive math as linguistically diverse students apply rules of their own in solving certain problems. Some of the applications might result in systematic math errors because of the interference caused by the language in which math is being processed.

When languages meet in a math classroom, teachers are faced with the challenging task of making students substantiate these meanings in their preferred way. If the language used does not make sense to the learner, the acquisition of math does not take place. Language is the major tool that communicates math concepts to the learners.

The linguistic cues in math lessons are significant to both learning and instruction (Winograd & Higgins, 1995). Generally, terms used in math lessons have several cultural connotations to the learner of math. Since "mathematics is a different and difficult subject to explain partly because of the language we use to communicate mathematical ideas and also because the ideas are not straightforward" (Khisty, 1992, p. 636), special considerations should be kept in mind when teaching mathematics in a multicultural setting.

Teacher's awareness of the problems encountered by learners of math in the linguistically diverse classroom, becomes the major step in helping students solve math problems in English. The issue here involves equitable pedagogical practices in math instruction. Thus, the less compatible instructional methods in mathematics classrooms have to be adapted in terms of the sociocultural and linguistic factors relevant to the learner. These challenges facing math teachers intensify in culturally diverse settings. Before we present pedagogical implications, it is helpful to consider the philosophical underpinnings that underlie math instruction.

The following assumptions underlie the discussion of math instruction in the culturally diverse environments

1. Students come to the class with informal information about mathematics
2. Students have their own preferred ways of learning math
3. Classroom settings hardly represent students' experiences
4. Reading a math problem does not necessarily mean understanding the logic behind it
5. Both reading and critical thinking are significant in math learning and instruction
6. There is a relationship between understanding math and the language used in math instruction

These assumption should be the foundation for any instructional techniques and other educational practices in dealing with students from diverse backgrounds. Also teachers should not have prior assumptions that are biased against the cultures represented in math classrooms.

Pedagogical Implications: Guidelines for Teachers

Effective communication is central in the learning process. The teacher is no longer a dictator of knowledge to be rotely memorized by students. Rather, learning involves complex psycho-social processes as participants interact in a given context (Vygotsky, 1978). Thus, the role of the teacher in the learning/teaching process is similar to the role of the parent at home as an "enabling other" in the learning process. This is especially true in multicultural settings where the basic premise of education is multiplying learning opportunities for all learners. In these settings, students and teachers work together to negotiate the meanings as they engage in a meaningful discourse. Teachers can help students individually and make students work in small and large groups so as they can learn cooperatively.

As far as math is concerned, researchers find Vygotsky's framework appealing. Learning in the Vygotskiian sense is a mediated activity in which children interact meaningfully with the world around them; this includes cultural patterns embedded in language and numeration. As (Khisty, 1992) put it, the "learning of mathematics is based on the essential ingredients of people engaged in communication for the purpose of developing shared meanings and understandings" (p. 664). Thus, the language used to communicate math concepts and meanings must make math comprehensible and less ambiguous.

Addison-Wiseley (1993) maintains that exploration and processing of mathematics by various cultures and the way first mathematicians operated should be reflected in today's math classrooms. The major task of math teachers in diverse classrooms is to engage students in culturally relevant tasks that help them process math from concrete experiences to making abstract generalizations. This includes hands-on activities, sensory experiences, reasoning and experimenting, and developing meaningful strategies to substantiate math concepts.

There are several areas where teachers can facilitate the learning of math in culturally diverse classrooms. Some of these are suggested below.

Solving Word Problems:

This requires teachers to employ reading skills to identify key words. The form and function of the basic mathematical symbols must be explained along with the usage of basic math vocabulary. Simple wording from the teacher makes it easy for students to grasp the abstract math concepts. Also, using basic words repeatedly forces students into acquiring some of the key concepts in mathematics. While some vocabulary in the mathematics classrooms includes technical jargon (Mather & Chiodo, 1994, p. 2), they have different cultural connotations as they take on new meanings when used in everyday contexts. Therefore, explaining the differences in meaning vocabularies is crucial to the understanding of mathematical problems.

Concrete Experiences:

It is a natural way of thinking and learning to employ several cognitive processes, such as associating, classifying, hypothesizing, comparing, observing . . .etc., when engaging in a learning task. Although these processes are universal, they may be shaped by the background experiences of the social milieu of the learner. Since these experiences will vary, using concrete objects and sensory experiences makes learning consistent with the thought patterns of alf individuals. Moreover, the context of learning is enriched as students engage in doing language and mathematics simultaneously. Literacy in math will emerge as students creatively use language to negotiate and create solutions to the math problem at hand. At the same time, the concrete experiences help students understand and develop logical reasoning naturally.

Group Activities:

Much has been said about cooperative learning in multicultural classrooms. In developing mathematical skills, peer learning can be extremely productive in that it cultivates cultural variables in learning and teaching mathematics (Lee & Slaughter-Defoe,

1995; King, 1995). First, students will work in a less threatening ambiance to create solutions as they are challenged by a math problem. Unlike doing math as an individual seatwork activity, there is more interaction in group-work. Second, in process, learners will be exposed to different learning styles as they become more conscious of their preferred ways of learning, thus opening their eyes to new ways of creating solutions. Needless to say, students gain more confidence in using language effectively as they interact mathematically.

Writing Activities:

These activities involve writing and rewriting mathematical problems. Students may be asked to rewrite a problem to other students "to clarify their understanding of the word problem" (Perez & Torres-Guzman, 1992, p. 123). Since writing is an act of discovery, students will be able to outline the logical processes conducive to mathematical problem solving. They also become more aware of the thought patterns suitable for particular mathematical problems. Teachers may encourage students to keep academic journals and learning logs to describe mathematical concepts. Finally, they can translate the concepts of math in a simple language that is meaningful to their students.

Songs and Rhymes:

Songs and rhymes are used in many languages to teach math. This will motivate students to learn the basic operations of math such as addition, subtraction, multiplication, and division. By attempting to maintain a rhythm, literacy in math emerges as it does in language arts. In so doing, children are "both playing with language and clarifying math concepts" (Perez & Torres-Guzman, 1992, p. 124). This added element of entertainment will help motivate children enhance their math and language skills simultaneously. In addition, it reduces the level of anxiety and frustration in math lessons.

Conclusion

The increasing diversity of the society we live in requires a drastic step in school reform to keep up with the evolving educational demands in today's technological society. Unless we see more culturally-correct pedagogy in math and science classrooms, we will continue to alienate language minority children and deprive mainstream students of benefiting from multiple learning opportunities. Since multicultural math combines human experiences and contributions in a universal context and rests on non-biased educational practices to prepare all students to become more math-competent in the ever-changing technological global society, teachers should carefully revise the curriculum and teaching practices, incorporate relevant experiential activities that nourish enriching scientific knowledge, and harness the merits of diversity in math classrooms.

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